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DILUTE GROUP III-V NITRIDE INTERMEDIATE BAND SOLAR CELLS WITH CONTACT BLOCKING LAYERS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/558,446, filed on Sep. 11, 2009, entitled "Dilute Group III-V Nitride Intermediate Band Solar Cells With Contact Blocking Layers," now U.S. Pat. No. 8,232,470, which is incorporated by reference herein in its entirety.

STATEMENT OF GOVERNMENTAL INTEREST

The invention described and claimed herein was made in part utilizing funds supplied by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. The government has certain rights in this invention.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The disclosure relates to solar cells and, more particularly, to dilute Group III-V nitride intermediate band solar cells with contact blocking layers to be used for improved solar cell performance.

2. Background Discussion

Solar or photovoltaic cells are semiconductor devices having P-N junctions which directly convert radiant energy of sunlight into electrical energy. Conversion of sunlight into electrical energy involves three major processes: absorption of sunlight into the semiconductor material; generation and separation of positive and negative charges creating a voltage in the solar cell; and collection and transfer of the electrical charges through terminals connected to the semiconductor material. A single depletion region for charge separation typically exists in the P-N junction of each solar cell.

Current traditional solar cells based on single semiconductor material have an intrinsic efficiency limit of approximately 31%. A primary reason for this limit is that a semiconductor has a specific energy gap that can only absorb a certain fraction of the solar spectrum with photon energies ranging from 0.4 to 4 eV. Light with energy below the bandgap of the semiconductor will not be absorbed and converted to electrical power. Light with energy above the bandgap will be absorbed, but electron-hole pairs that are created quickly lose their excess energy above the bandgap in the form of heat. Thus, this energy is not available for conversion to electrical power.

In accordance with one or more embodiments, the dilute III-V nitride p-n junction materials for the IBSC comprise layers of GaNAs, and the contact blocking layers are lattice matched to a desired band gap of the GaNAs layers. In one or more embodiments, the contact blocking layers comprise at least one of AlGaAs or other III-V ternary alloys. In one or more embodiments, the composition of the AlGaAs contact blocking layer is tuned so that its conduction band is aligned with the upper sub-band of the GaNAs absorber layers. By isolating the IBand of the GaNAs absorber layers in this manner and effectively blocking the intermediate band from contact with neighboring layers, the IBand only acts as a "stepping stone" for the absorption of the lower energy photons and hence increases the short circuit current (ISC) of the device. The open circuit voltage (VOC) of a IBSC is determined by the largest gap of the GaNAs. In one or more embodiments, the p-n junction absorber layers of the IBSC

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may further have compositionally graded nitrogen concentrations to provide an electric field for more efficient charge collection.

SUMMARY

The disclosure relates to solar cells and, more particularly, to dilute Group III-V nitride intermediate band solar cells with contact blocking layers to be used for improved solar cell performance.

In accordance with one or more embodiments, an intermediate band (IBand) solar cell (IBSC) is provided comprising at least one p-n junction based on dilute III-V nitride materials and a pair of contact blocking layers positioned on opposite surfaces of the p-n junction. The contact blocking layers provide electrical isolation of the intermediate band of the p-n junction by blocking the charge transport in the IBand of the p-n junction without affecting the electron and hole collection efficiency of the p-n junction. In one or more embodiments, the IBSC is formed on a substrate or as a solar cell within a larger, multi-junction tandem cell.

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Many other features and embodiments of the present invention will be apparent from the accompanying drawings and from the following detailed description.

DRAWINGS

The above-mentioned features and objects of the present disclosure will become more apparent with reference to the following description taken in conjunction with the accompanying drawings wherein like reference numerals denote like elements and in which:

FIG. 1 is a block diagram representation of an intermediate band solar cell (IBSC) in accordance with one or more embodiments of the present disclosure.

FIG. 2 is a graphical illustration of a calculated band diagram for one embodiment of the IBSC shown in FIG. 1, in accordance with one or more embodiments of the present disclosure.

FIG. 3 is a graphical illustration of a calculated carrier profiles for one embodiment of the IBSC shown in FIG. 1, in accordance with one or more embodiments of the present disclosure.

FIG. 4 is a block diagram representation of a test structure of an intermediate band solar cell (IBSC) in accordance with one or more embodiments of the present disclosure.